

FIGURE 1. An example showing common ancestors in reptiles. X and Y are species that were the common ancestors between later-evolved forms.

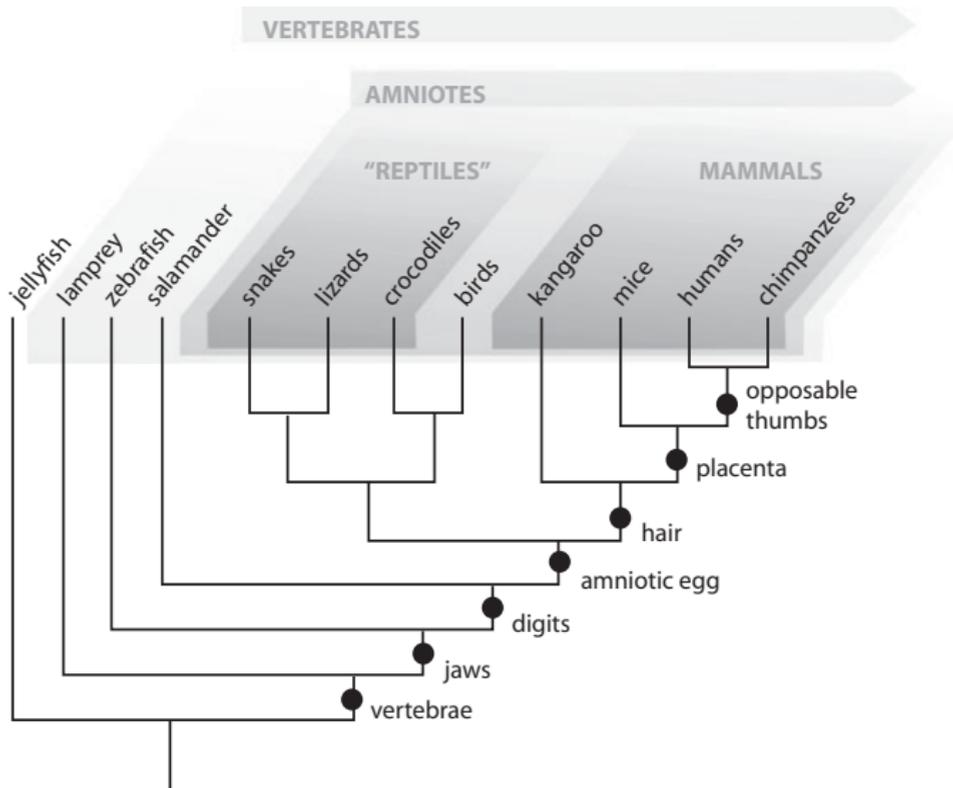


FIGURE 2. A phylogeny (evolutionary tree) of vertebrates, showing how evolution produces a hierarchical grouping of features, and thus of species containing these features. The dots indicate where on the tree each trait arose.

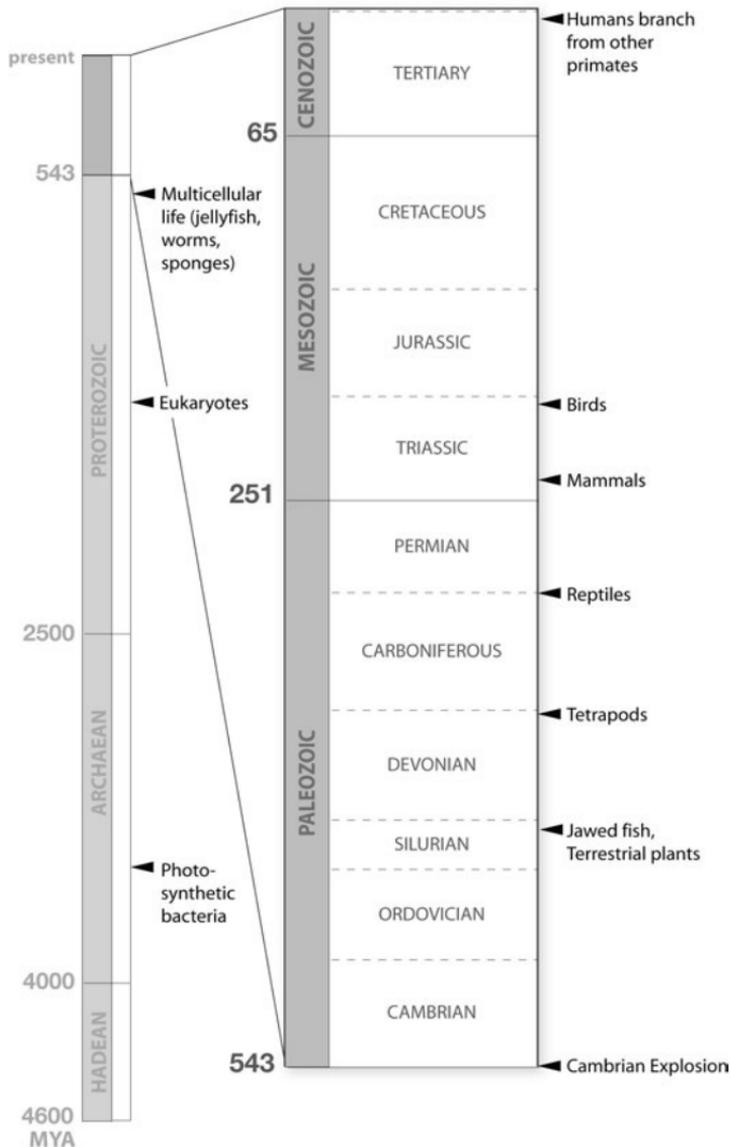


FIGURE 3. The fossil record showing first appearance of various forms of life that arose since the Earth formed 4,600 million years ago (MYA). Note that multicellular life originated and diversified only in the last 15% of life's history. Groups appear on the scene in an orderly evolutionary fashion, with many arising after known fossil transitions from ancestors. The sequence shown, along with the transitional forms, disproves creationist claims that all forms of life arose not only suddenly, but also at the same time.

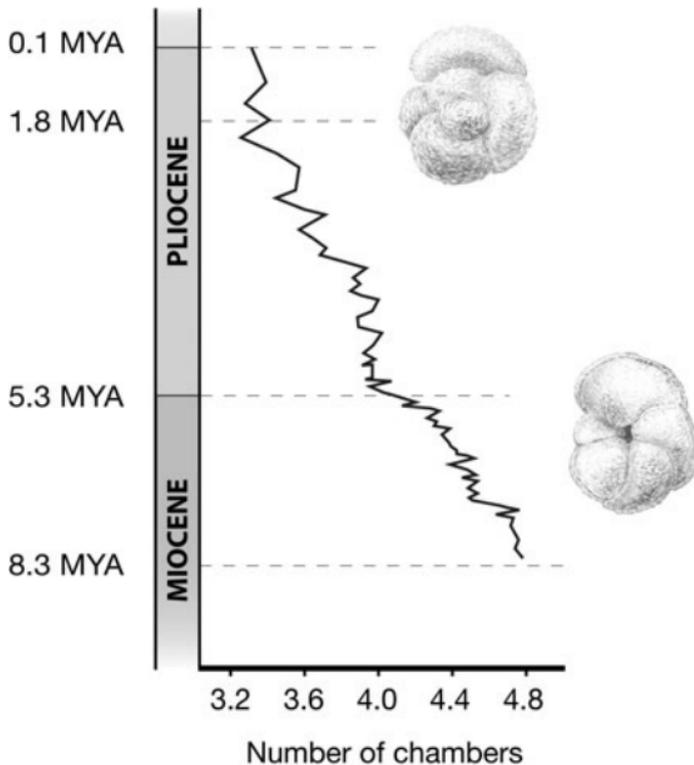


FIGURE 4. A record of fossils (preserved in a sea-floor core) showing evolutionary change in the marine foraminiferan *Globorotalia conoidea* over an 8 million-year period. The scale gives the number of chambers in the final whorl of the shell, averaged among all individuals from each section of the core. (After Malmgren and Kennett 1981.)

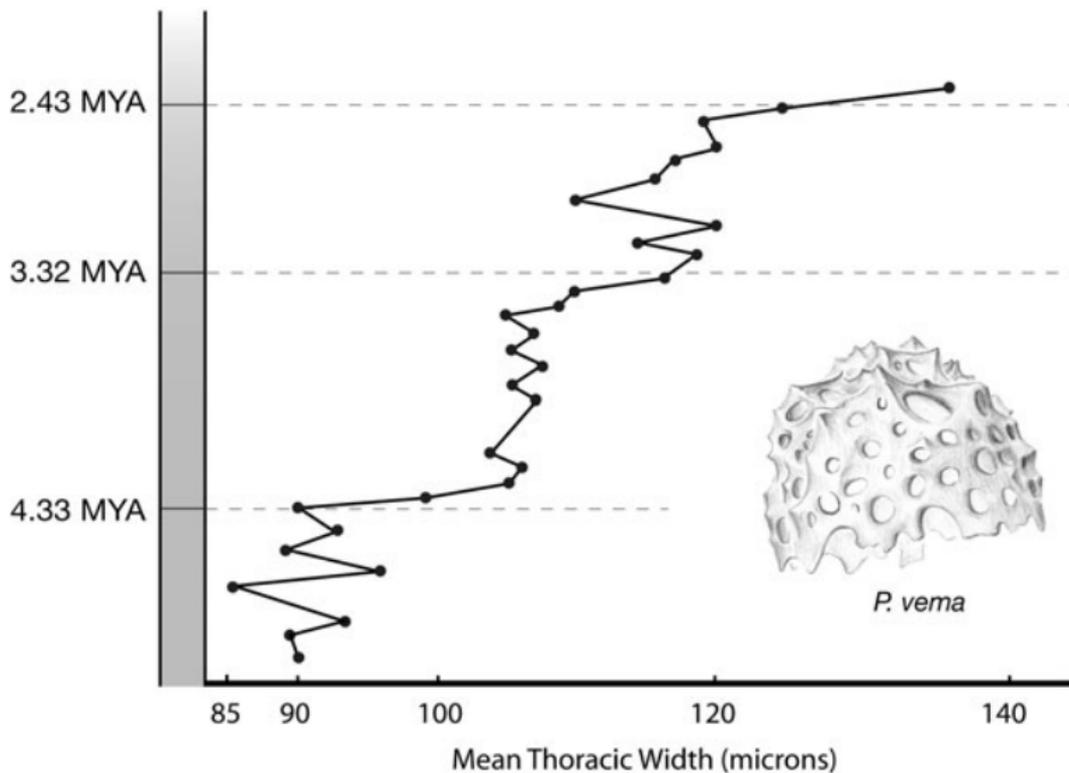


FIGURE 5. Evolutionary change of thorax size in the radiolarian *Pseudocubus vema* over a period of two million years. Values are population averages from each section of the core. (After Kellogg and Hays 1975.)

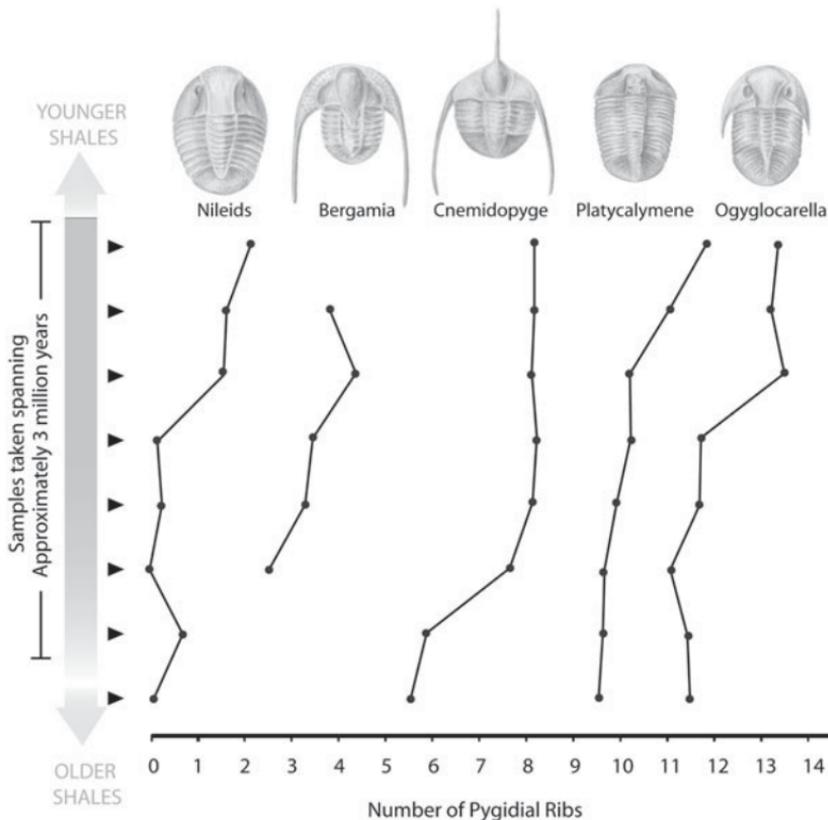


FIGURE 6. Evolutionary change in the number of pygidial ribs (segments on the tail section) of five groups of Ordovician trilobites. The number gives the population average at each section of the three-million-year sample of shale. All five species—and three others not shown—displayed a net increase in rib number over the period, suggesting that natural selection was involved over the long term, but that the species did not change in perfect parallel. (After Sheldon 1987.)

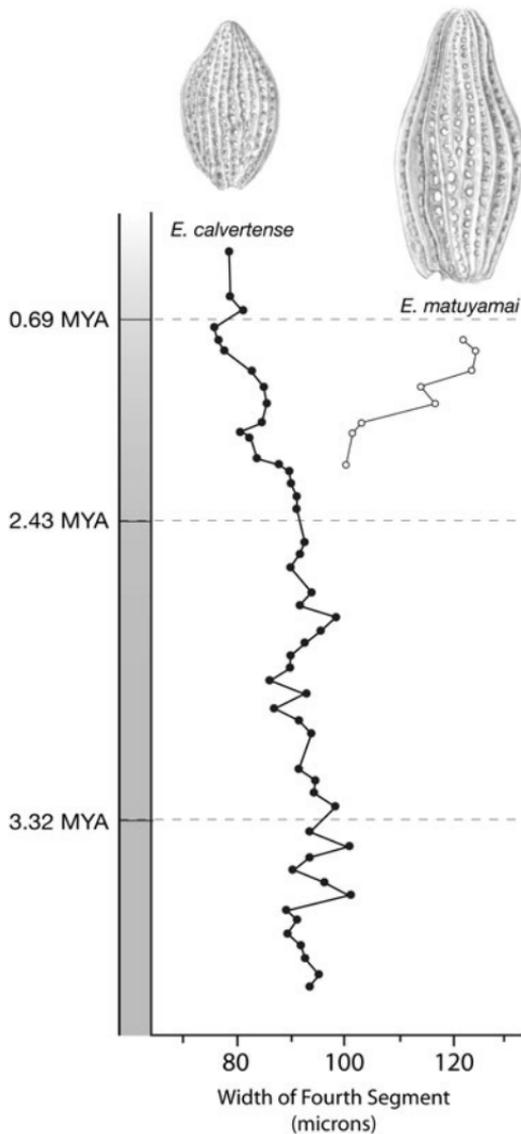


FIGURE 7. Evolution and speciation in two species of the planktonic radiolarian *Eucyrtidium*, taken from a sediment core spanning more than 3.5 million years. The points represent the width of the fourth segment, shown as the average of each species at each section of the core. In areas to the north of where this core was taken, an ancestral population of *E. calvertense* became larger, gradually acquiring the name *E. matuyamai* as it became larger. *E. matuyamai* then reinvaded the range of its relative, as shown on the graph, and both species, now living in the same place, began to diverge in body size. This divergence may have been the result of natural selection acting to reduce competition for food between the two species. (After Kellogg and Hayes 1975.)

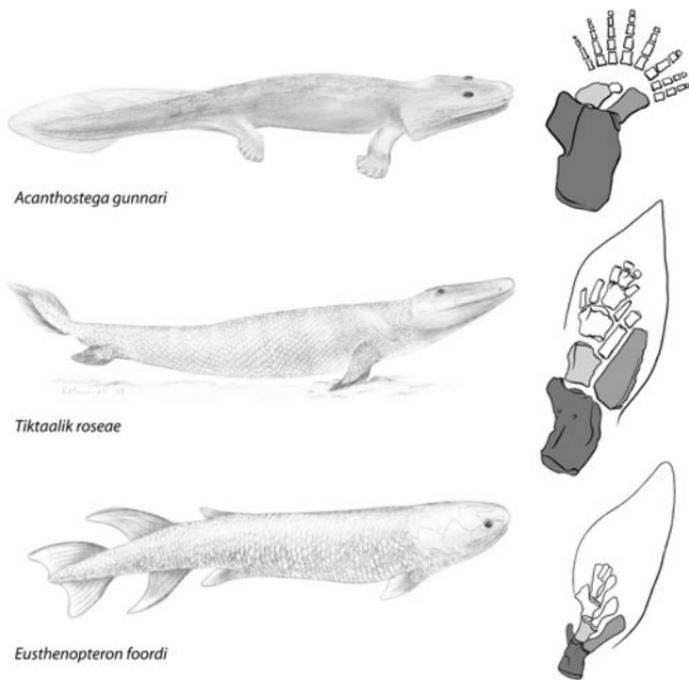
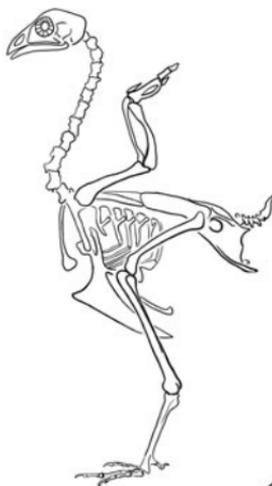


FIGURE 8. Invasion of the land. A land-dwelling tetrapod (*Acanthostega gunnari*) from Greenland, about 365 million years ago. An early lobe-finned fish (*Eusthenopteron foordi*) from about 385 million years ago, and the transitional form, *Tiktaalik roseae*, from Ellesmere Island, about 375 million years ago. The intermediacy of *Tiktaalik*'s body form is mirrored by the intermediacy of its limbs, which have a bone structure in between that of the sturdy fins of the lobe-finned fish and the even sturdier walking limbs of the tetrapod. Shaded bones are those that will evolve into the arm bones of modern mammals: the bone with darkest shading will become our humerus, and the medium- and light-shaded bones will become the radius and ulna, respectively.

chicken



Archaeopteryx



Compsognathus

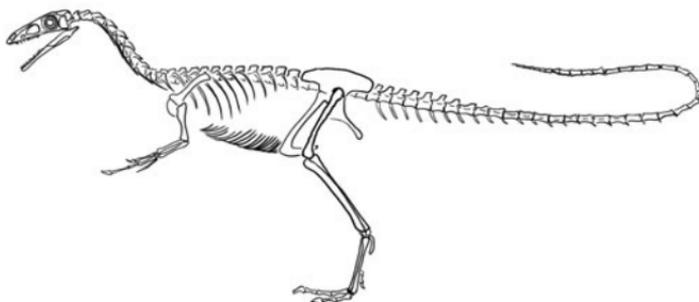


FIGURE 9. Skeletons of a modern bird (chicken), a transitional form (*Archaeopteryx*), and a small, bipedal, carnivorous theropod dinosaur (*Compsognathus*), similar to one of *Archaeopteryx*'s ancestors. *Archeopteryx* has a few features like those of modern birds (feathers and an opposable big toe), but its skeleton is very similar to that of the dinosaur, including teeth, a reptilian pelvis, and a long bony tail. *Archaeopteryx* was about the size of a raven, *Compsognathus* slightly larger.

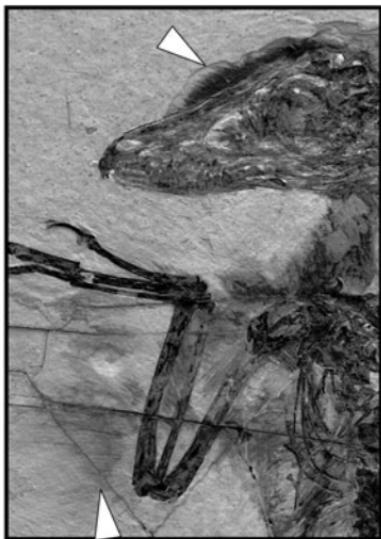


FIGURE 10A. The feathered dinosaur *Sinornithosaurus millenii*, original fossil (about 125 million years old) from China, and artist's reconstruction. The fossil clearly shows the impression of filamentous feathers, especially on the head and forelimbs.

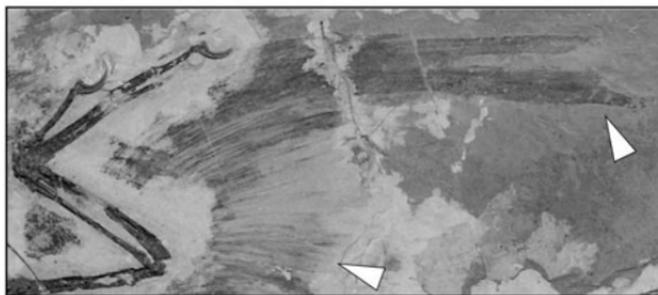


FIGURE 10B. The bizarre “four-winged” dinosaur *Microraptor gui*, which had long feathers on both its fore- and hindlimbs. These feathers are clearly visible in the fossil, dated about 120 million years ago. It’s not clear whether this animal could fly or only glide, but the rear “wings” almost certainly helped it land, as shown in the drawing.



FIGURE 11. Fossil behavior: the feathered theropod dinosaur *Mei long* (top) fossilized in a birdlike roosting position, sleeping with its head tucked under its forelimb. Bottom: a reconstruction of *Mei long* from the fossil.

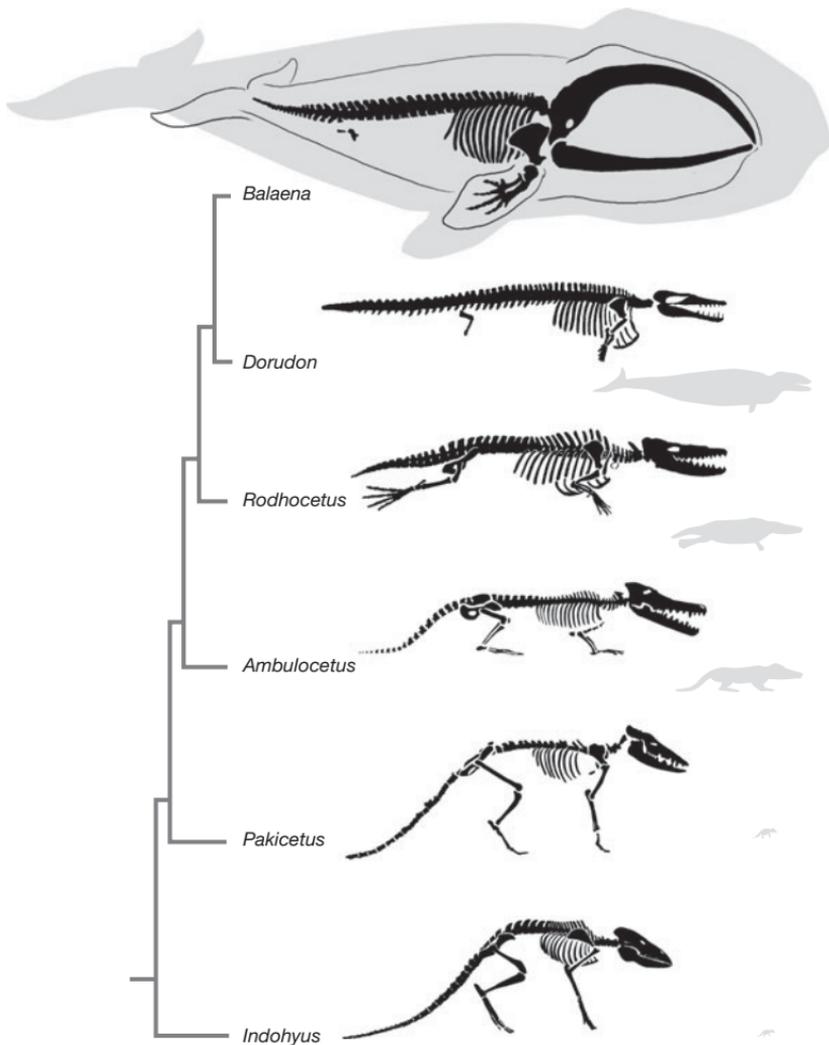


FIGURE 12. Transitional forms in the evolution of modern whales from the ancient artiodactyl *Indohyus* (*Balaena* is the modern baleen whale, with a vestigial pelvis and hindlimb, while the other forms are transitional fossils). Relative sizes of the animals are shown in gray shading.

Sphecomyrma freyi

- ▷ ancestral traits
▶ derived traits

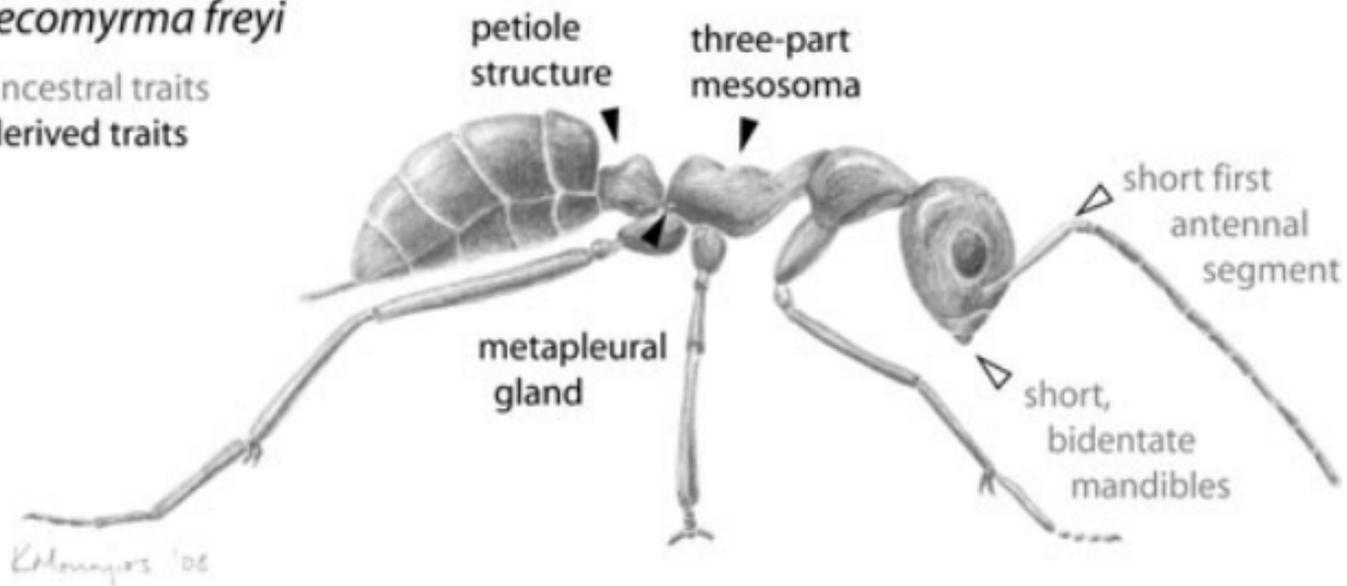


FIGURE 13. Transitional insect: an early ant showing primitive features of wasps (open triangles), its predicted ancestor, and derived features of ants (filled triangles). A single specimen of this species, *Sphecomyrma freyi*, was found preserved in amber dating from 92 million years ago.



FIGURE 14. Vestigial and atavistic tails. Top left: in our relatives that have tails, such as the ruffed lemur (*Varecia variegata*), the tail (caudal) vertebrae are unfused (the first four are labelled C1–C4). But in the human “tail”, or coccyx (top right), the caudal vertebrae are fused to form a vestigial structure.

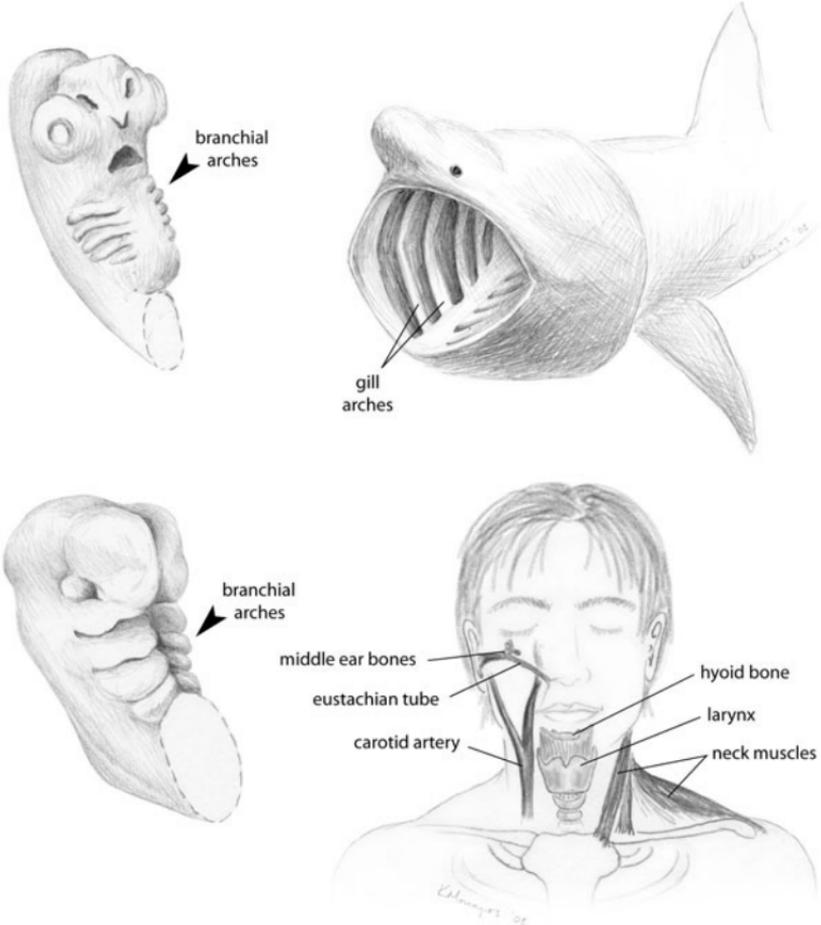


FIGURE 16. Branchial arches of a shark embryo (top left) and a human embryo (bottom left). In sharks and fish (such as the basking shark *Cetorhinus maximus* shown at top right), the arches develop directly into the adult gill structures, while in the human (and other mammals) they develop into diverse structures in the adult head and upper body.

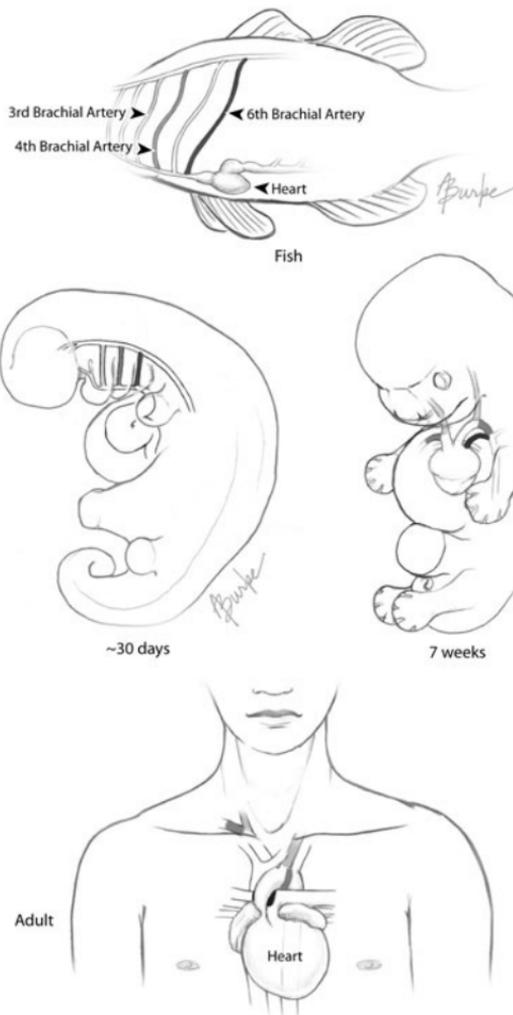


FIGURE 17. The blood vessels of embryonic humans start out resembling those of an embryonic fish, with a top and bottom vessel connected by parallel vessels, one on each side (“aortic arches”). In fish, these side vessels carry blood to and from the gills. Embryonic and adult fish have six pairs of arches; this is the basic ground plan that appears at the beginning of development of all vertebrates. In the human embryo, the first, second, and fifth arches form briefly at the beginning of development, but disappear by 4 weeks of age, when the third, fourth, and sixth arches (distinguished by different shades of gray) form. By 7 weeks, the embryonic arches have rearranged themselves, looking much like the embryonic vessels of a reptile. In the final, adult configuration, the vessels are rearranged still more, with some having vanished or transformed themselves into different vessels. The aortic arches of fish undergo no such transformation.

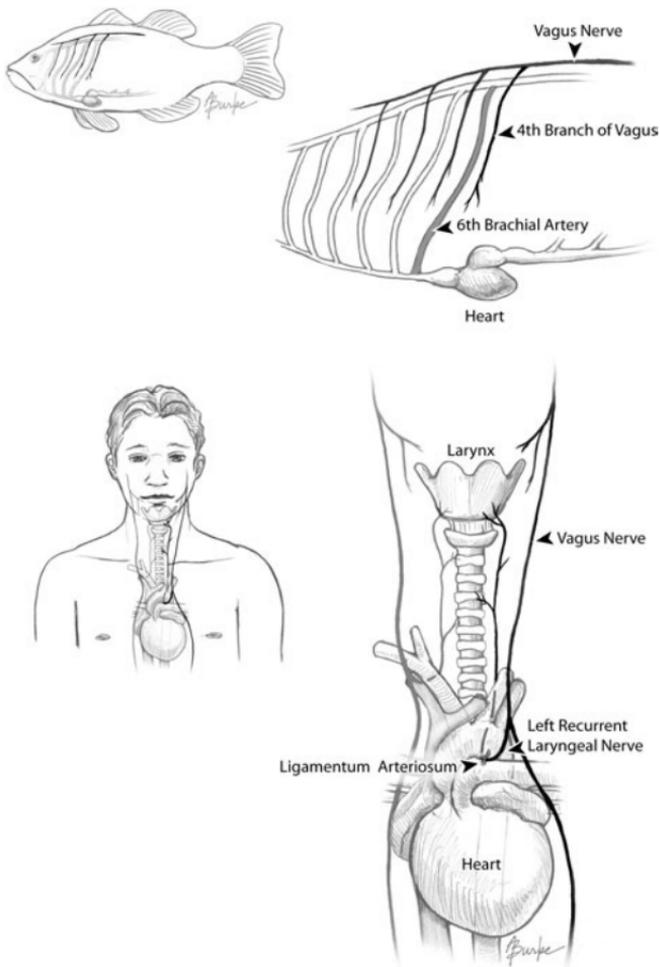


FIGURE 19. The circuitous path of the left recurrent laryngeal nerve in humans is evidence for their evolution from a fishlike ancestor. In fish, the sixth branchial arch, which later becomes a gill, is served by the sixth aortic arch. The fourth branch of the vagus nerve runs behind this arch. These structures remain part of the gill apparatus in adult fish, innervating and bringing blood from the gills. In mammals, however, part of the branchial arch evolved into the larynx. The larynx and its nerve remained connected during this process, but the sixth aortic arch on the left side of the body moved down into the chest to become a nonfunctional remnant, the *ligamentum arteriosum*. Because the nerve remained behind this arch but still remained connected to a structure in the neck, it was forced to evolve a pathway that travels down into the chest, loops around the aorta and the remnants of the sixth aortic arch, and then travels back up to the larynx. The indirect path of this nerve does not reflect intelligent design, but can be understood only as the product of our evolution from ancestors having very different bodies.



MARSUPIALS



PLACENTALS



Sugar glider



Flying squirrel



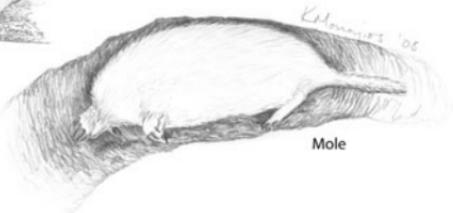
Banded anteater



Anteater



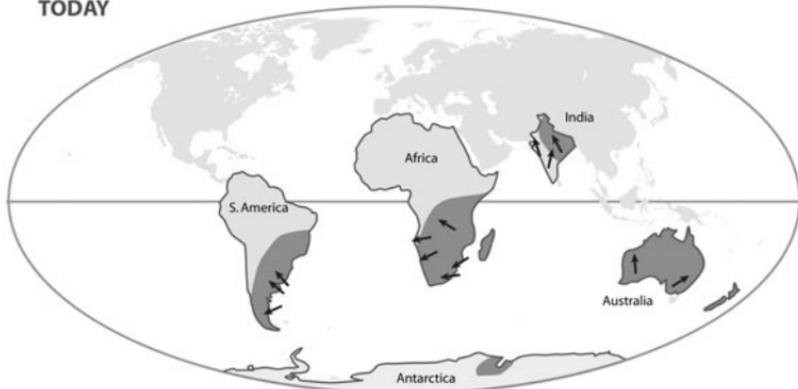
Marsupial mole



Mole

FIGURE 20. Convergent evolution of mammals. Marsupial anteaters, small gliders, and moles evolved in Australia, independent of their placental-mammal equivalents in the Americas, yet their forms are remarkably similar.

TODAY



PERMIAN

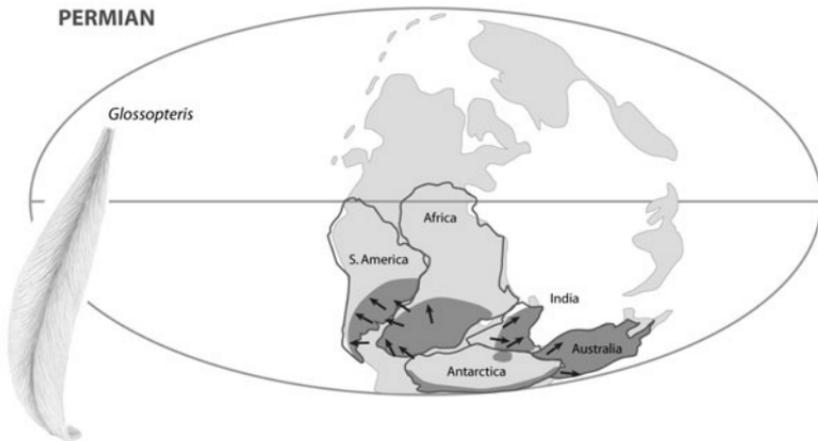


FIGURE 21. Continental drift explains the evolutionary biogeography of the ancient tree *Glossopteris*. Top: the present-day distribution of *Glossopteris* fossils (shaded) is broken up into pieces distributed among the continents, making it hard to understand. The patterns of glacial scratches in the rocks are likewise mysterious (arrows). Bottom: the distribution of *Glossopteris* during the Permian, when the continents were joined in a supercontinent. This pattern makes sense because the trees surrounded the Permian south pole in an area of temperate climate. And the glacial scratches we see today also make sense, as they all pointed away from the Permian south pole.

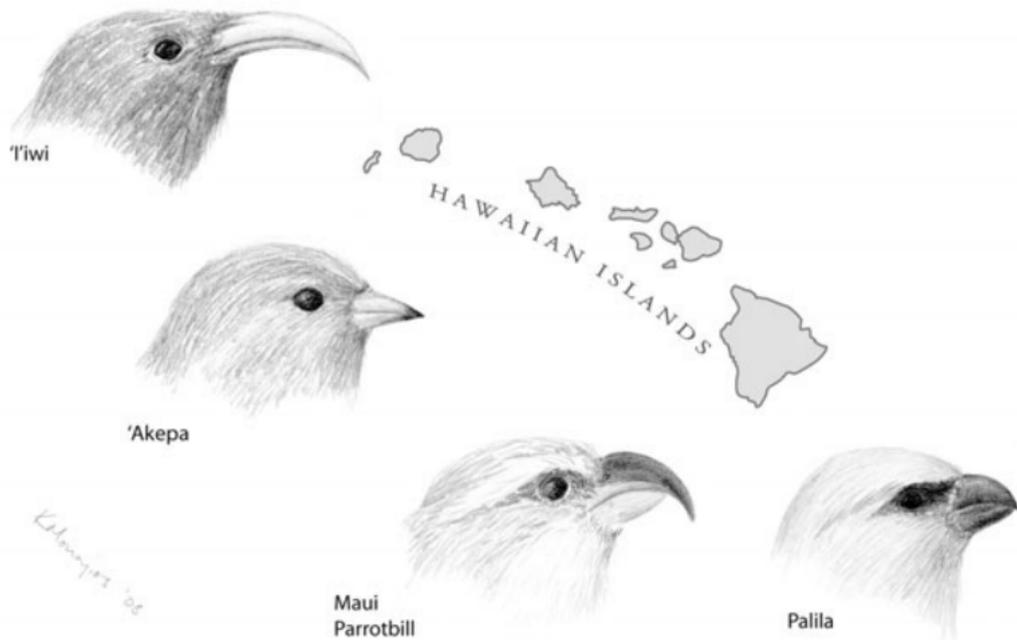


FIGURE 22. An adaptive radiation: some related species of Hawaiian honeycreepers that evolved after their finchlike ancestor colonized the islands. Each finch has a bill that enables it to use different food. The 'i'iwi's slender bill helps it sip nectar from long tubular flowers, the 'akepa has a slightly crossed bill that allows it to pry open buds to search for insects and spiders, the Maui parrotbill has a massive bill for prying up bark and splitting twigs to find beetle larvae, and the palila's short but strong bill helps it open seed pods and extract the seeds.

Native**Missing**

Plants

Land mammals

Birds

Reptiles

Insects and other
arthropods (e.g., spiders)

Amphibians

Freshwater fish

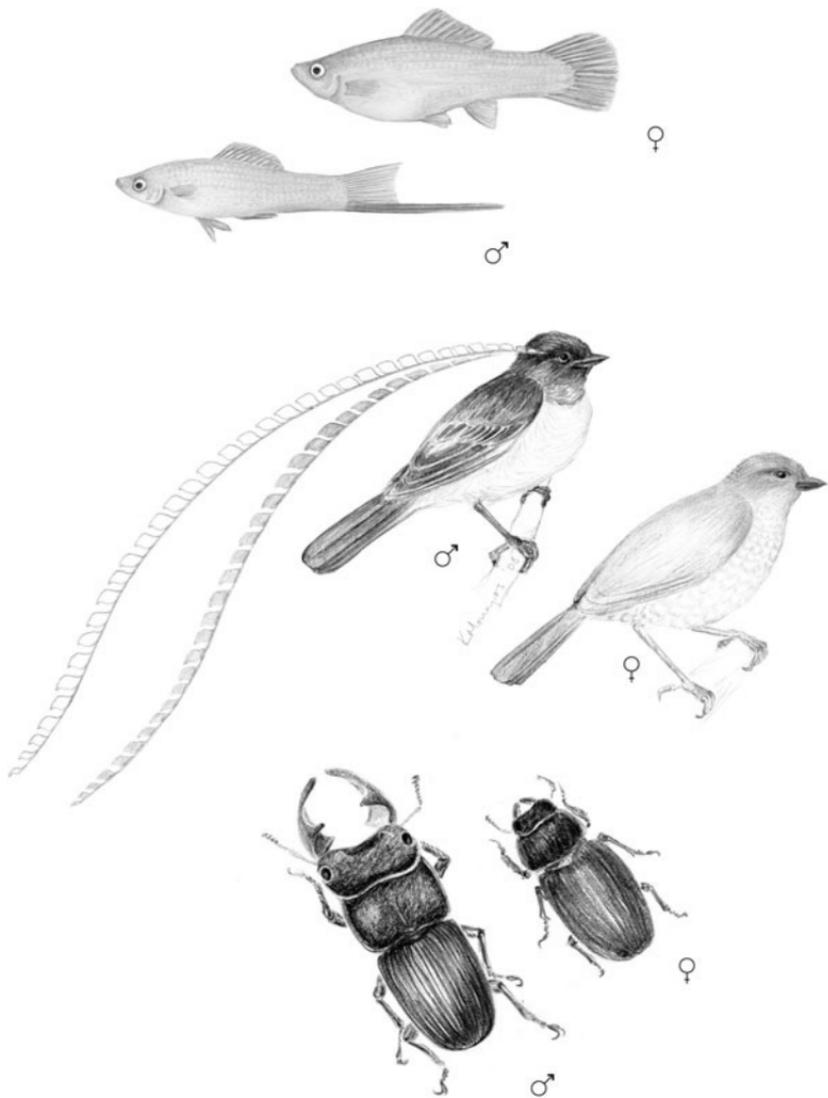


FIGURE 23. Examples of sexual dimorphisms, showing marked differences in the appearance of males and females. Top: the swordtail (*Xiphophorus helleri*); middle: King of Saxony Bird of Paradise (*Pteridophora alberti*), whose males have elaborate head ornaments that are sky blue on one side and brown on the other; bottom: the stag beetle *Aegus formosae*.

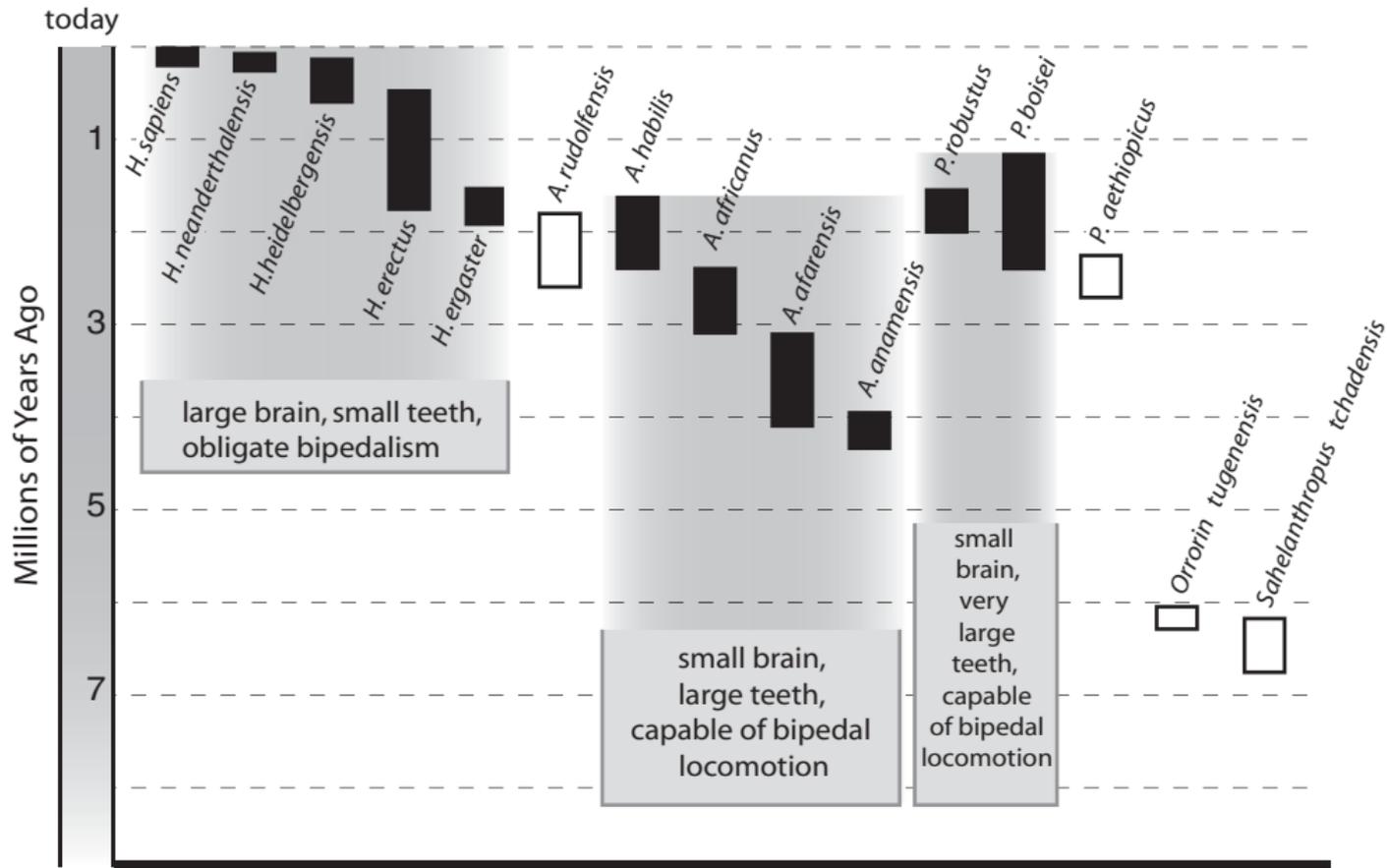


FIGURE 24. Fifteen hominin species, the periods over which they occur as fossils, and the nature of their brain, teeth, and locomotion.

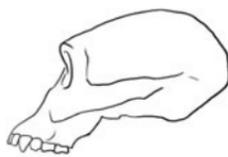
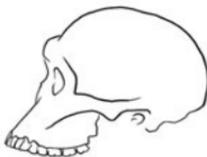
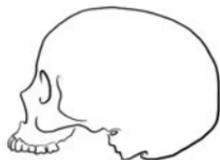
Homo sapiens



Homo habilis



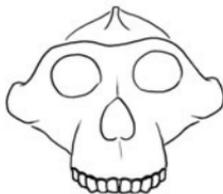
Australopithecus afarensis



Sahelanthropus tchadensis



Paranthropus boisei



Pan troglodytes
(chimp)

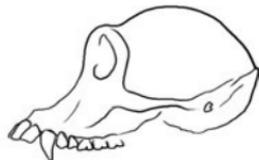
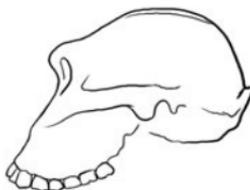
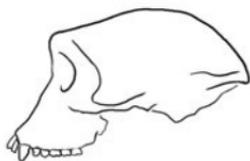


FIGURE 25. Skulls of modern humans (*Homo sapiens*), earlier hominins, and a chimpanzee (*Pan troglodytes*).

Homo sapiens

Australopithecus afarensis

Pan troglodytes
(chimp)

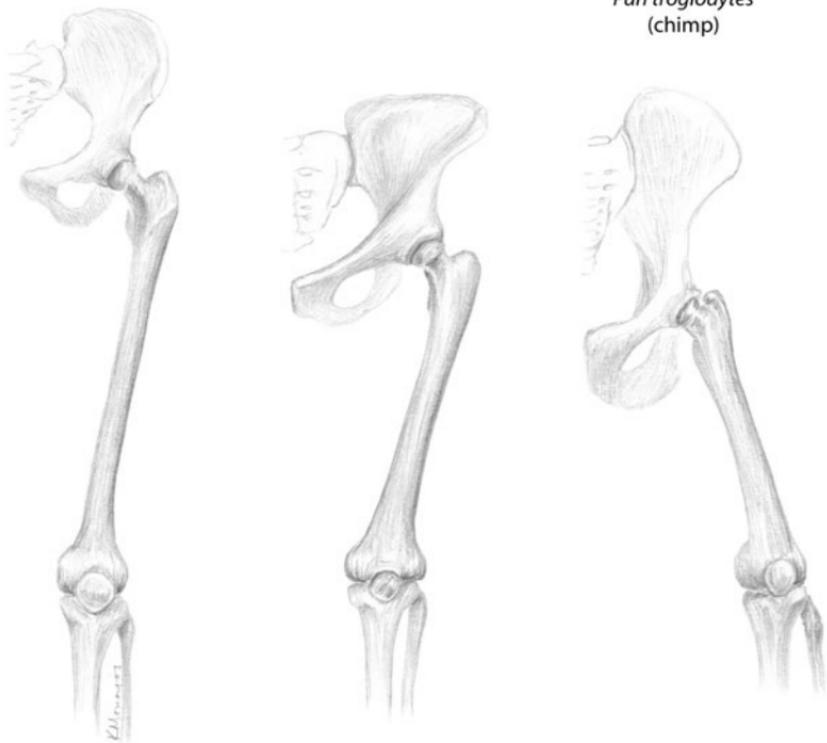
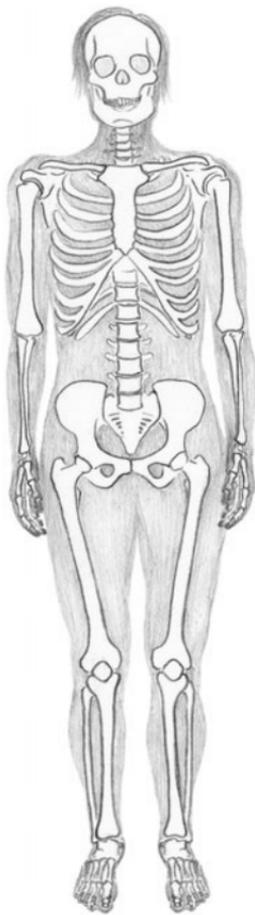


FIGURE 26. The attachment of the femur (long leg bone) to the pelvis in modern humans, chimps, and *Australopithecus afarensis*. The pelvis of *A. afarensis* is intermediate to the other two, but its inward-pointing femur—a sign of upright walking—resembles that of humans and contrasts with the splayed femur of the knuckle-walking chimp.



Homo sapiens



Australopithecus afarensis



Pan troglodytes
(chimp)



FIGURE 27. The skeletons and dental arcades of modern *Homo sapiens*, *Australopithecus afarensis* (“Lucy”), and a chimpanzee. While chimps are not the ancestors of the human lineage, they probably resemble the common ancestor more than do humans. In many respects *A. afarensis* is intermediate between the apelike and human morphology.